Assessment of a Cooperative Workstation

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Groupware and new Information Technologies have now made it possible for people in different places to work together in synchronous cooperation. Very often, designers of this new type of software are not provided with a model of the common workspace, which is prejudicial to software development and its acceptance by potential users. The authors take the example of a task of medical co-diagnosis, using a multi-media communication workstation. Synchronous cooperative work is made possible by using local ETHERNET or public ISDN Networks. A detailed ergonomic task analysis studies the cognitive functioning of the physicians involved, compares their behaviour in the normal and the mediatized situations, and leads to an interpretation of the likely causes for success or failure of CSCW tools.

INTRODUCTION

Organization functioning has been transformed by network servers and data base computer tools, word-processing, electronic messaging and records systems. But whereas computers have enhanced individual productivity, they seem to have failed to support the cooperative environment to which they have been applied [1].
Groupware development (i.e. of computers or systems designed for cooperative work) is aimed at overriding the artificial gap that has arisen from designers' consistent focusing on the user as an individual by reintegrating the user into a wider social and cooperative dimension [1].

However, whereas the designers' intuition was all that was needed to develop single-user computers and software, and could even bring about real success for a given use [2], it is far from being enough where the development of this new generation of tools is concerned. Hence the emergence of a new subject known as " computer-supported cooperative work" (CSCW) [3].

However, Grudin [4] stresses that the first systems and applications designed to support groupwork shared two characteristics: considerable financial and human investments and a rate of success well under expectancies. Three major causes seem to lead to such failure:
1- Applications are a failure because they require extra work of certain people which does not benefit these persons directly, leading them to sabotage the system. The same thing occurs where applications fail to take into account the amount of improvisation characteristic of group dynamics, or where due to ignorance, social taboos are ignored or the organization's existing structure is endangered.
2- They are a failure when designers have not shown enough understanding of multi-user systems. Designers grasp easily the potential benefit their peers (i.e. other members of the managerial sphere) can derive from such systems, but are quite unable to apply this to other categories of users.
3- They are a failure because learning by experience is difficult. Their introduction within an organization generates hardly avoidable obstacles to significant and generalizable analysis and to assessment because it is difficult to differenciate the motivating economical and political factors that are present within a group and which undoubtably affect the functioning of the groupware.

Other hypotheses have been made [5,6]: failures could be due to the use of an incorrect implicit model of conversation, the "parcel" model. In this model, conversation is seen as a certain number of bits of verbal and/or textual information, transmitted as a whole from one person to another. Messages are thus created, "packaged" and sent out with no reference to the exact moment when they were created and to how they are distributed. This

0195—4210/96/$5.00

"parcel" model makes establishing a shared reference for a given message difficult and reduces the reliability of exchanges.
To function successfully, groupware should be developped using an interactive model of conversation. In this model conversation is defined as a complex and highly coordinated process in which participants strive to reach mutual understanding through the proposal and acceptance of coordinated statements. Synchronicity plays an essential part in this process.

Current research on groupware development has only lead to design recommendations. But an effort is being made to formalize these specifications, as in the case of the WYSIWIS concept defined by Stefik, or the Ishii and Miyake's concept of "open shared workspace" [7]. For these last authors, a shared workspace is called "open" where none of the new technologies in use impede the potential use of existing methods and work tools. Albeit general, these concepts can be applied to any situation.

These design specifications are a must if groupware is to be a success. Actually a prototype development irrespective of these specifications seems to be one of the major causes for failure. On the contrary, their use leads to successful functioning, although this functioning may be incomplete. The prototypes of Video-Draw and Team-Workstation [7] are typical examples. The latter, a groupware prototype designed to support the cooperative task of drawing, was developped partly from Tang's research work.

It is therefore essential to assess that the cooperative functions of the medical groupware are correctly implemented and do not interfere with the activity of the physician. To verify the USABILITY of the workstation by the involved physicians, we propose an assessment methodology based upon the comparison of the medical behaviour in the two environments:
(1)in the natural situation
(2) in the mediatized situation.

AIM OF THE STUDY: ASSESSMENT OF THE CO-DIAGNOSIS PROCESS

The aim of this study is to realise an ergonomic and cognitive assessment of a computer tool designed for cooperative work in the field of medical images.

We have taken the example of a co-decision process in Nuclear Medicine: the interpretation of myocardial scintigraphy. Myocardial tomo-scintigraphy is used in nuclear medicine to study the perfusion of the myocardium. A radioactive isotope (in this case, Thallium 201) is injected to the patient and ischemic parts of the myocardium can then be differentiated with reference to the areas of hypofixation. Usually two series of images are obtained: one just after a stress test, and another one at rest in order to assess the vitality of the myocardium under these two conditions.

The interpretation of cardiac scintigraphy is a difficult task, which often requires the complementary opinion of experts who have a huge experience. In this sense, interpretation is frequently a cooperative task.

The purpose of the cooperative workstation [8] was to make the process of co-decision easier where two physicians are physically distant but need to discuss the same document (in this case one or more pictures) to reach a diagnosis. Documents assessed by the medical experts are complex and only multi-media stations allowing the simultaneous handling of text, sound, voice and still or animated pictures can be an answer to this problem. Such communicating multi-media stations are now widely available in the medical world, even if their use is limited to some applications.

We will consider two levels of assessment:
1- An ergonomy level, geared at station usability and adequation to the needs of the medical users. This will mostly cover the quality of the human-machine interface.
2- A cognitive level where we plan to analyze workspace, cooperation and co-decision.

HYPOTHESES

Diagnosis can be defined as a problem-solving activity in which the basic material is information and ideas. In consequence, successful cooperation requires simultaneous access to information for the partners and easy exchanges between them.
In this particuler context we make a hypothesis that the use uf the workstations will not modify the cooperative activity of diagnosis as compared to a face-to-face situation.

This hypothesis can be tested on two levels:
1- The workspace
2- The actual diagnosis.

MATERIAL AND METHODS

Subjects

Six voluntary physicians took part in this experience. They all belong to the same Nuclear Medicine Department in the University Hospital. Three are recognized experts, they are referred to by the letters E1, E2, and E3. All three are highly experienced in the interpreting of myocardical tomo-scintigraphy. The three others, N1, N2 and N3 are young physicians in the training process to be specialized in nuclear medicine. Although they have practiced in this field, they are not so used to interpreting myocardial scintigraphy. These physicians meet in pairs, thus defining three types of dyads: Expert-Expert (E1-E2, E1-E3, E2-E3), Expert-Novice (E1-N1, E2-N2, E3-N3) and Novice-Novice (N1-N2, N1-N3, N2-N3).

Material

a) The multi-media stations

Each station, linked to a telephone, is made of a PC 486 computer, two high definition video monitor (Screen 1 for text and files management, Screen 2 for images display), a keyboard, a mouse and a video camera for the acquisition of the pictures [8]. The stations a equipped with specific boards for the management of multimedia functions (DVI Intel boards) and communication facilities (PCSNet board). Both stations are linked together through the ISDN network.
This workstation allows the following functions:
- The management of the files and the communications is done through a dedicated software displayed on screen 1
- display of the medical record on screen 1
- display of the images of the record on screen 2 which is a common workspace between the two connected worktations
- telepointing with the mouse
- teledrawing (circling, writing, ...)

b) Clinical files and assessment sheets

Each clinical file contains two series of SPECT images (one for stress-time and one for rest-time) and a record of the basic medical data. Scintigraphs are pictures of the heart taken by three cross-sections (small and great vertical cross-sections, great horizontal cross-section). In total, 24 pictures are interpreted (3 times 4 cross-sections x the two testing times).
55 files are used. They are picked at random, before the experience by an expert who is asked to sort them from difficult to easy. In this way, 24 files are considered difficult.

The physicians' answers are reported onto a standardized diagnosis

The Experience

1 For each cooperative experience, 8 files are randomly selected from the 55 available medical records: 4 difficult ones and 4 easy ones.

2 The second stage of the procedure is the actual experiment. A few days prior to this, each subject is trained to use the station. On the actual day, and before each session of natural or mediatized cooperative work, both subjects study, on their own, all the medical records which they are then going to work on together.

In the natural situation, the subjects are sitting side by side at a table. They are provided with the medical images, the patients' medical files and the diagnosis sheets. Files are presented to them in a random order. The physicians are given no other instruction but to reach a common diagnosis and to come to an agreement as to which boxes to tick on the diagnosis sheets. ***In the mediatized situation***, subjects are placed in two separate rooms where the stations are set up. They cannot see each other and can only communicate through the telephone and the station. They are provided with the same type of documents as in the natural situation. These documents are digitalized and stored in the stations. They are given at random to one of the two physicians who sends them to the other by ISDN before the cooperative interpretation phase.

Four pairs (N1-N2, E3-N3, E1-E2, E2-E3) begin with the mediatized situation and the four others with the natural situation.

Observation Protocols

Two video-cameras are used to film each of the two partners in face-to-face (natural) or mediatized situation. In order to analyse these films, an observation grid is designed in which both subjects' gestures and looks are linked up with each element of speech. After viewing the films, three units of behaviour were chosen: taking a document,

exchanging documents and pointing out on a document. The same grid is used in natural and in mediatized situation which makes it easy to compare subject behaviour depending on whether they are working side by side or at a distance.

RESULTS

Human Computer Interface

The use of the station was found very simple and easy to learn by all users. Each procedure, i.e. selecting pictures, connecting and disconnecting the two stations, is based on a small number of handlings, always identical for a given procedure and which therefore can easily be made automatic.

- Selecting pictures requires four actions, all using the mouse.
- The connecting procedure takes only three actions on the keyboard, and is guided by a menu and help messages.
- We observe that some 40 seconds elapse between choosing a file and the partner's phone ringing.
- In the same way, disconnecting is based on three elementary actions. This procedure takes less than 10 seconds.

Workspace analysis: Comparison of the natural and the mediatized situations.

1) The natural situation

Subjects work sitting side by side at a table. As they settle down, their very first task is to share out the roles: laying out the pictures, filling in the diagnosis sheet. Analysis of the observation grids for this stage leads to the following results. Whatever the dyad:

1) Pictures are placed in the middle of the pair and require the subjects' complete visual attention. There is no occurence of prolonged conversation during which the partners look at each other.
2) There is no case of individual study beforehand. Subjects work together from the onset.
3) 3)The sheet of clinical data is read aloud by one of the partners. Only dyad N1-N2 does not use it.
4) Picture analysis is supported by a "single action" - we refer to Tang's concept (1989). This action consists in indicating an area of the heart.
5) The actor uses a pen to indicate the particular area by pointing, underlining or circling.
6) Each pointing is supported by a verbal comment in the form of an adverbial or nominal complement defining location.
7) Actions mostly bear two functions:
   - supporting argumentation
   - asking a question.
8) Less usually, they are used to
   - attract attention
   - ask the partner for information on localization.

In every case, actions go along with verbalizations related to the stage reached by the diagnosis process.

2) The mediatized situation

In the mediatized situation, subjects are isolated and communicate only by means of tele-pointing, tele-drawing, and vocal exchanges through the telephone.

During cooperative work, three phases are made obvious.

1-3) The two extreme phases concern communication management (connecting and disconnecting). In the connecting phase, discussion is geared at two objectives. The aim is first to synchronize the actions of the two partners because successful connecting depends on this. After this, the partners check that communication is established properly by making sure two cursors have appeared and/or are mobile on the screens. In the last phase (disconnecting), conversation is still geared at synchronizing the partners' actions but also at checking that the analysis of the file on hand is really completed.

2) The middle phase is where diagnosis is actually reached. Contrasted analysis of the pairs leads to the following results.

Whatever the dyad:

1) The clinical sheet is is read aloud. It is not used by the pair N1-N2.
2) In a majority of cases, cooperation is limited to the single action of pointing on the screen with the telepointer.
3) Subjects indicate a particular area by using the mouse to point, underline or circle. Only two cases are observed (N1 and N3) where the subject uses his pen to point at the pictures.
4) Each pointing is supported by a verbal comment in the form of an adverbial or nominal comment defining location.
5) Actions mostly bear two functions: supporting argumentation and asking questions.
6) Pointing is only used in rare cases to attract attention (6 cases) and only by subject E1.

7) Four cases are observed where one of the subjects asks his partner to name the area he is discussing.

3) Comparing both situations

Comparing both situations does not lead us to find fundamental differences between the two workspaces during picture analysis. Subjects seem to point at the pictures as often in the natural situation as in the mediatized situation: 428 pointings are observed in the former, 397 in the latter.

Also, the action of pointing and the functions it bears are maintained. No significant increase is observed in the mediatized situation, of the number of questions concerning localization (85.2 / 88 questions per dyad) or of requests specifically aimed at attracting attention (1.5 / 0.3 questions per dyad).

What's more, the station improves cooperation in two ways. It enables users to manipulate the images to allow a better view of the images (by zooming on special areas, for example), as was observed in dyad N1-N3. It also offers subjects the possibility of drawing real lines, for instance to represent a cross-section, whereas they have to draw imaginary lines in the natural situation.

DISCUSSION AND CONCLUSION

With the development of Telemedicine [9,10], it becomes important to evaluate the impact of this new Information Technology on the medical activity. The methodology using the comparison of natural and mediatized situations to assess the quality of cooperative workstations appears as an essential phase in the development of such interactive medical applications

In our experience, the cooperative workstation maintains the necessary functionalities:
- First functionality : "verbal exchanges". Subjects can speak to each other through the station just like in the natural situation. Therefore, the same actions can be activated in both situations.
- Second functionality : "pointing". In the mediatized situation, actions like pointing with fingers or pens, etc... are impossible. These natural actions are replaced by the pointing action using the telepointing facility offered by the workstation, using the mouse. The function of this action is found to be strictly identical to the natural pointing function and as efficient.

The ergonomical analysis of the station has shown that it makes for a collaboration just as convivial and efficient as the natural situation. This efficiency and conviviality can be explained by two parameters:
- the necessary functionalities are maintained
- actions of a same group of fuctions are easily interchangeable when the station is unable to maintain the natural actions.

But i t must also be stressed that the assessment of a workstation often has to take into account socio-cognitive factors, such as hierarchy-related social relations, between partner users. This parameter, already identified by Grudin [1] has no incidence on the station assessed in the present study, but can in certain cases become a strong setback.

Aknowledgements

This work was done as part of the "Contrat Etat-Région Nord -Pas-de-Calais Communication Avancée" which subsidized the "Ganymède" group of inter-laboratory research.

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